Delta Membranes

Flood Resilience (PFR)

INNOVATION | MANUFACTURER | DESIGN | SOLUTION

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NBS Source

ABOUT US

Delta Membranes Systems Limited

Delta Membrane Systems Limited is a manufacturer and provider of specialist structural waterproofing solutions, covering Types A, B and C waterproofing, combination waterproofing, damp proofing, basement drainage, flood resilience and ground gas protection.

We aim to deliver excellence by putting our customers at the heart of everything we do.

Delta unites innovative products with highly skilled waterproofing design specialists. Our in-house team of technical consultants support our clients in providing comprehensive, reliable, and expert advance, identifying, and mitigating risk and establishing opportunities for added value.

Our projects include commercial and residential structures, new-build and refurbishment, housing developments and civil infrastructure. Our technical consultants cater to a diverse client base, including architects, developers, contractors, sub-contractors, engineers, and homeowners all centred on latest industry guidance, current legislation, standards, and best practice.

Delta proudly supports the Women of Waterproofing Networking Group. An independent networking group that promotes gender equality in the waterproofing sector, seeking to inspire, retain and attract females.

Delivering world-class solutions, Delta is an impeccable partner on every project.

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We have a dedicated, multi-disciplinary team creating, innovative, robust, and reliable waterproofing solutions. We strive for excellence and manufacturing synergy, utilising each team member's individual skills and own unique approach on design, collaborating to achieve exceptional results.

The Delta Specification team works with architects, designers, contractors, and engineers. Our team provides full consultation services, including CSSW Specification Reports. We offer advice on how Delta specifications can promote the successful outcome of any project.

With extensive experience in the field of structural waterproofing, we draw upon knowledge and expertise to offer totally flexible on-site support. As part of our commitment to innovate through the development of best practice, our on-site support will complement any existing design and installation team. We aim to help support and develop the skills of your technicians and, if required, will also provide bespoke onsite training for your technical teams.

What is PFR?

Property Flood Resilience (PFR) is an important process to assess the potential flood risk to a building and reduce the impact of a flood event.

Property Flood Resilience (PFR) covers measures that can be taken to reduce flood damage and speed up recovery and reoccupation of a previously flooded structure. PFR measures typically aim to minimise the amount of water entering a building (known as resistance measures), reduce the potential for flood water to cause damage to its fabric (known as resilience measures) and thereby speed up safe re-occupation time (known as recoverability measures). Flood resilience strategies can include all the above approaches (known as combining resistance, resilience, and recoverability measures). PFR strategies can aim to prevent water entry or reduce the amount of floodwater that enters a property. PFR Products can be purchased and installed as permanent or temporary. Permanent products are fitted, left in place, and remain 'always ready' to protect a structure 24/7, with no action needed to activate them in the event of a flood. Temporary measures are usually stored away and then put in place when flooding is expected.

Examples of PFR measures that can be used on a structure include:

- Flood barriers
- Structural Waterproofing Products and Applications
- Internal fixtures and fittings (such as resilient kitchens/tiled floors/raised appliances and power sockets)
- Self-closing Air bricks
- Flood Dams
- Non-return valves

It is widely accepted that PFR measures cannot always stop flood water entering a building, but they can reduce the disruption and damage caused when a flood event does occur.

Properties Suitable for PFR Measures

Whether a property is historic or heritage, a business or residency. All are suitable for PFR measures.

Successful Aproaches to PFR

- Understand your flood risk
- Understand the impact of a flood event
- Understand the different measures available to limit flood damage
- Use experienced professionals for guidance on measures that suit your structure/budget or business needs
- Use experienced installing contractors
- Understand the future maintenance of the PFR measure
- Make sure the experienced professionals you use are trained, certified, and well versed in established codes of practice and that your PFR solution meets these.

The table below is derived from Table 4 of **BS 85500:2015 Flood resistant and resilient construction – Guide to improving the flood performance of buildings**.

	Design Water Depth*	Approach	Mitigation Measures
Resistance / Resilience**	Design Water Depth above 0.6m	Allow water through property to avoid risk of structural damage. Attempt to keep water out for low depths of flooding **'Water Entry Strategy.'****	• Materials with low permeability up to 0.6m • Accept water passage through building at higher water depths • Design to drain water away after flooding • Access to all hidden voids and spaces to permit drying and cleaning
	Design Water Depth from 0.3m to 0.6m	Attempt to keep water out, in full or in part, depending on structural assessment. If structural concerns exist follow approach above***	• Materials with low permeability to at least 0.3m • Flood resiliant materials and designs • Access to all spaces to permit drying and cleaning
	Design Water Depth up to 0.3m	Attempt to keep water out. **'Water Exclusion Strategy.'**	• Materials with low permeability
Avoidance		Remove building development from flood hazard.	• Land raising, landscaping, raised thresholds

Notes:

* Design water depth should be based on assessment of all flood types that can impact on the building

** Resistance/Resilience measures can be used in conjunction with Avoidance measures to minimise overall flood risk

*** In all cases the 'water exclusion strategy' can be followed for flood water depths up to 0.3m, but flood resilience measures should also be included for ground water flooding and longer duration events

The table below is derived from Table 4, page 15, section 6 of **BS 85500:2015 Flood resistant and resilient construction – Guide to improving the flood performance of buildings.**

Selection of Strategy

Design flood water depth above ground floor level [A]	Strategy
Less than 300mm	Resistance [B]
300mm to 600mm	Resistance + resilience
More than 600mm	Resistance + resilience for lesser events

Notes:

[A] See 6.1.

[B] Groundwater and long duration flooding could additionally require resilience.

BRITISH STANDARDS

BS 85500:2015

British Standard 85500:2015 Flood resistant and resilient construction – Guide to improving the flood performance of buildings.

BS 85500:2015 gives recommendations and provides guidance for improving the flood resistance and resilience of buildings in order to minimise impacts of flooding through appropriate design strategy, local planning and risk assessment, construction methods and materials.

BS 85500:2015 is applicable to various different building types and scenarios, including retrofitting of existing properties, extensions, and new builds.

BS 85500:2015 further recommends that the most successful design strategies are to plan for both water exclusion and water entry.

Choice of Strategy

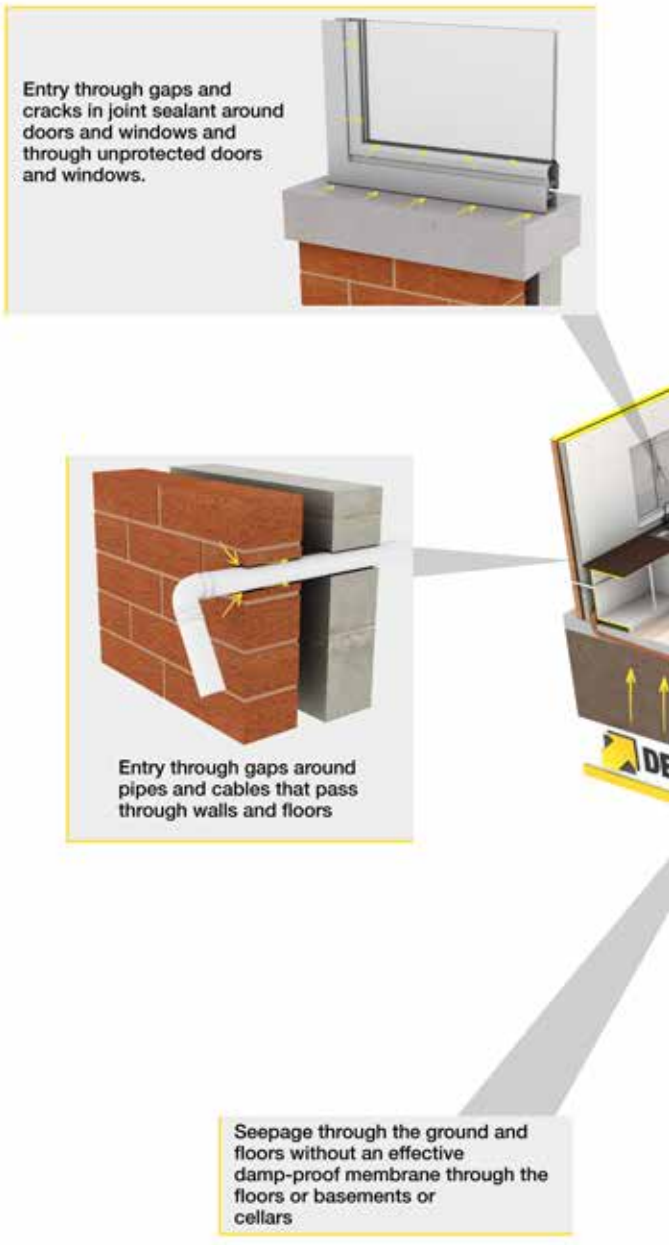
BS 88500:2015 offers a choice of strategies when designing flood recoverable solutions:

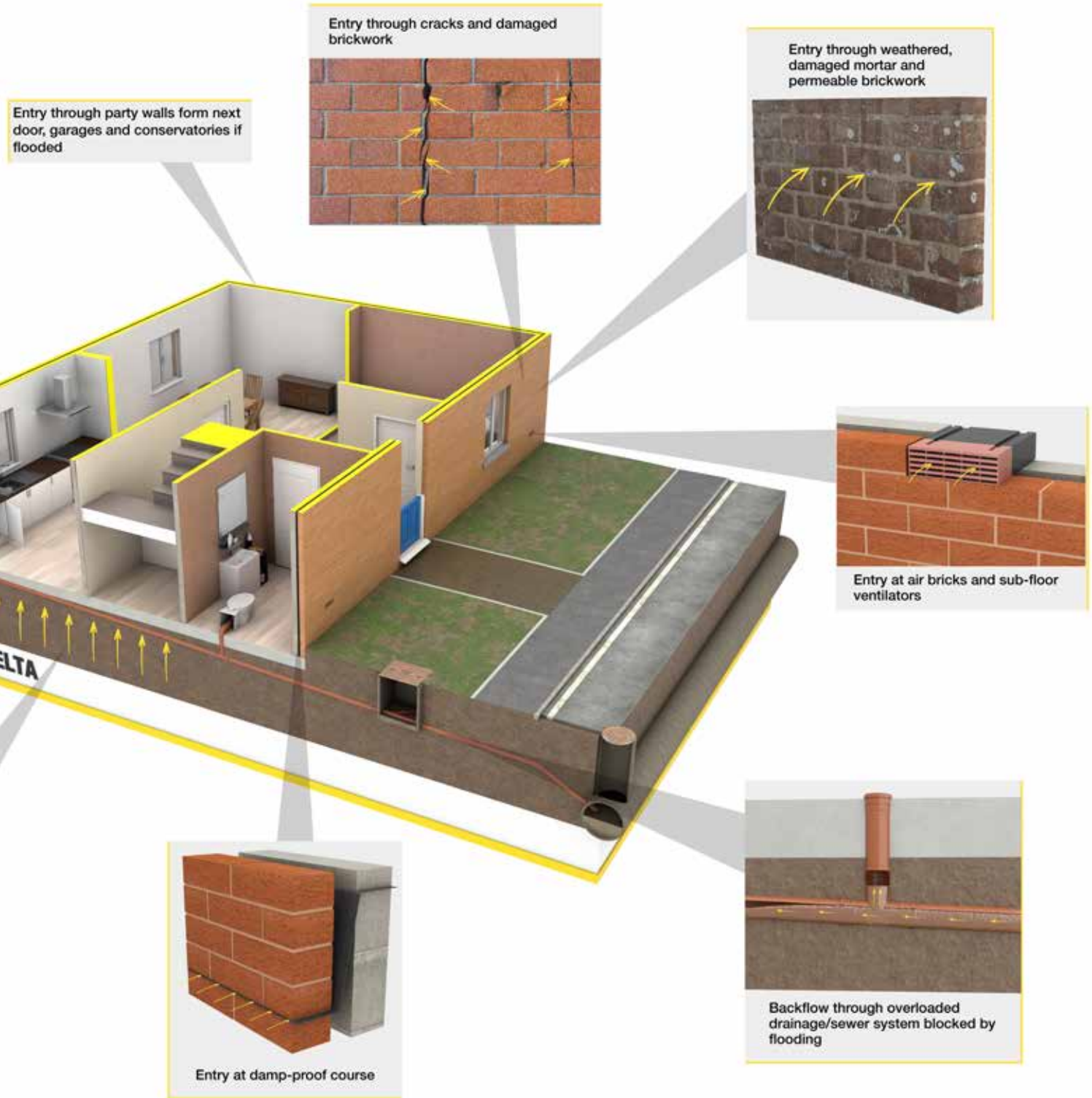
- Avoidance
- Mitigation
- Water Exclusion (Flood Resistance)
- Water Entry (Flood Resilience)

Design Options

The simplest water exclusion measure is to build the ground floor above the maximum level that any flood water is likely to reach (known as "flood avoidance"). However, this is clearly impractical where structures have already been built and planners may not approve of a new build being disproportionately higher than neighbouring properties. Where the potential flood level is below 300mm **(see Table 4 of BS 85500:2015 - previous page)**, there are a number of relatively simple ways of sealing off the inside and keeping a structure more or less dry.

A common option is to use tanking; a continuous waterproof layer applied within the wall and floor construction that aims to prevent flood water from seeping into rooms. However, it must be remembered that the most successful flood resilience strategies may plan for water exclusion, but also allow for water entry, because the depth and duration of any given flood is by nature unpredictable.




Entry through party walls form next door, garages and conservatories if flooded
Entry through cracks and damaged brickwork
Entry through weathered, damaged mortar and permeable brickwork
Entry at air bricks and sub-floor ventilators
Backflow through overloaded drainage/sewer system blocked by flooding
Entry at damp-proof course

SOURCES OF FLOODING

Source, Pathways and Receptors

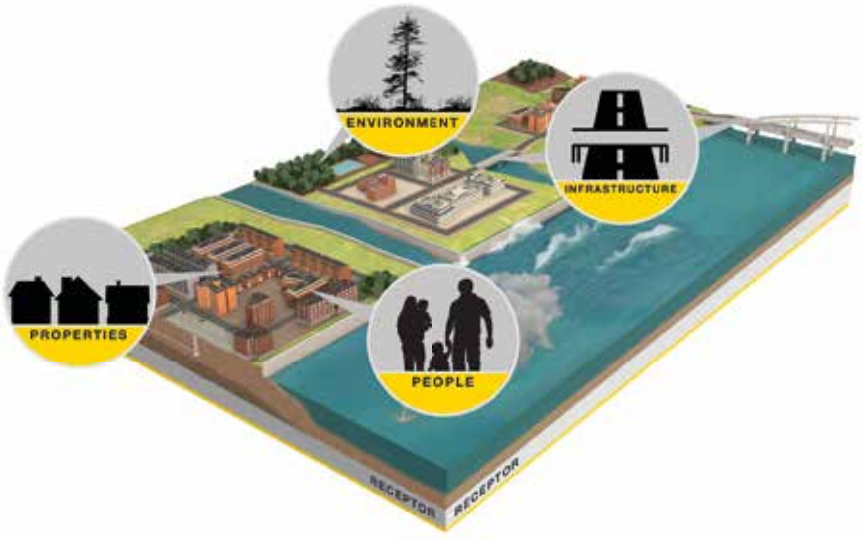
Sources of Flooding

The following actions should be undertaken in accessing sources of flooding:

- Identify the 'source of flooding' If it is likely to come from a nearby watercourse, groundwater, sewer, water management asset or coastal area.
- Identify the pathway. How does the flood reach the Receptor.
- Identify the Receptor. Example, if a property, business or people will be affected by a flood event.

Understanding Source, Pathways and Receptors

All potential sources of flooding should be considered when assessing a property. This assessment should include all sources, along with pathways flood water will take, including the probability of flood events and flood events which could exceed the proposed flood defences. Understanding all possible sources and the nature of a flood event is critical for assessing the flood hazard at any location.



Types of Flooding

Types of Flooding	Definition
River Flooding	River flooding, also known as fluvial flooding, occurs when the capacity of a river's channel is exceeded because of intense or sustained rainfall across the catchment.
Groundwater Flooding	Groundwater flooding occurs when the water table rises to the surface during a prolonged wet period. Low lying areas, areas near aquifers and properties with cellars or basements are more likely to experience groundwater flooding.
Surface Water Flooding	Surface water flooding, also known as pluvial flooding, occurs when the volume of rainfall is unable to drain away through the drainage systems or soak into the land and instead flows over land. Blocked drains and sewers can increase the risk of surface water flooding as the water has nowhere to go.
Coastal Flooding	Simply put, a coastal flood is when the coast is flooded by the sea. The most common cause of coastal flooding in the UK is storm surges, where the storm wind pushes the water up and creates high waves.
Sewer Flooding	Most sewerage flooding incidents are the result of overloaded sewers following heavy rainfall or blockages caused by misuse of the sewerage system such as flushing unsuitable items down the toilet.
Reservoir Flooding	Reservoir flooding can be similar to river and surface water flooding if the water escapes slowly. However, in the unlikely event of a dam wall failing, a large amount of water could escape. It could happen with little or no warning and you may need to evacuate immediately.
Burst Water Mains	The signs of a burst water mains pipe are instantaneous and obvious. Water main breaks usually result from external corrosion of the pipe. Extreme weather changes can cause the ground to swell and contract, placing excessive pressure on the water mains, causing any weakened pipe to break.

Flood Risk

What is a Flood Risk?

"Flood risk" is a combination of the probability that a flood may occur and the potential severity of the consequences of a flood event. Areas at risk of flooding are those at risk of flooding from any source, now or in the future. Sources can include rivers, the sea, direct rainfall on the ground surface, rising groundwater, overwhelmed sewers and drainage systems, reservoirs, canals and lakes and other artificial sources. Flood risk also accounts for the interactions between different sources, as a flood event can occur from a combination of sources simultaneously.

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 0.1% annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map for Planning - all land outside Zones 2, 3a and 3b).
Zone 2 Medium Probability	Land having between a 1% and 0.1% annual probability of river flooding; or land having between a 0.5% and 0.1% annual probability of sea flooding. (Land shown in light blue on the Flood Map).
Zone 3a High Probability	Surface water flooding occurs when the volume of rainfall is unable to drain away through the drainage systems or soak into the land and instead flows over land. Blocked drains and sewers can increase the risk of surface water flooding as the water has nowhere to go.
Zone 3b The Functional Floodplain	This zone comprises land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise: • Land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively; or • Land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding). Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map).

(Above table derived from National Planning Policy Framework 2021)

Surface Water / Surface Water Run Off

Surface Water / Surface Water Run off

Surface water flooding occurs chiefly as a result of natural precipitation. It is a buildup of free water upon the surface of the land, and should not be confused with groundwater flooding, which is a localised temporary extreme rise in water table.

Surface water can be measured in terms of annual runoff. This represents the amount of rain and snow melt left following planned drainage and natural take-up processes, such as absorption and evaporation from land.

Typically, surface water flooding (also known as pluvial flooding) is caused by short duration, very intense rainfall, or longer periods of very sustained rainfall. These excessive volumes of rainfall temporarily exceed the capacity of existing drainage infrastructure and land absorption to take it away, and instead it can build up, surcharge and flow overland. The intensity of this type of flooding can be increased by blocked road gullies, drains and sewers, already saturated and waterlogged land, and by presence of hard, non-absorbent surfaces, such as roads and driveways.

Often, there is limited advance notice of surface water flooding owing to its often sudden and localised nature. Due to the sporadic and intense nature of surface water flood events, resulting damage can be extensive.

Surface Water Drainage

Sunken external areas such as patios or light wells are especially vulnerable to surface water flooding. We recommend that, especially where the total internal surface area exceeds 12m2, a dedicated packaged pump station should be specified in accordance with relevant calculations, and incorporated into the project to deal with surface water. This in addition to any separate internal pump stations designated to deal with ground water ingress through the structure.

Drainage systems should be designed in accordance with relevant codes and standards.

Effects of Flood on a Structure

Effects of Flood on a Structure

Damage caused to a building by flooding can be significant. Short-term cleaning up costs can be high, and any residual trapped water and moisture can cause longer term damage and even health risks.

Typical effects of a flood event on a building include:

- Direct deterioration of materials, components and elements resulting in immediate change of their form and properties without returning to their previous condition after drying.
- Direct structural damage caused by the depth, duration and velocity of flood waters on the building structure, including debris impact.
- Inundation or saturation of materials that cannot be dried or recovered economically on site.
- Indirect secondary damage, such as mould growth and other problems arising from high atmospheric moisture.


VULNERABLE HOUSE AFTER FLOOD

Assessing Risk and Reducing Risk

ASSESSING FLOOD RISK

Flood Risk Assessment will include analysis of all potential sources of flooding at a site and the potential impact of a flood event on a building. Around 5.5 million buildings in the UK are in danger of being flooded. That's approximately 15% of properties built near to rivers, the sea or areas of extreme surface water run-off caused by local ground conditions – the latter of which are often in places that aren't physically close to open water. An accurate assessment of flood risk will offer ways to assess how flood water may enter a structure.

There are a number of typical routes via which floodwater may enter a property. Potential routes for entry of flood water include:

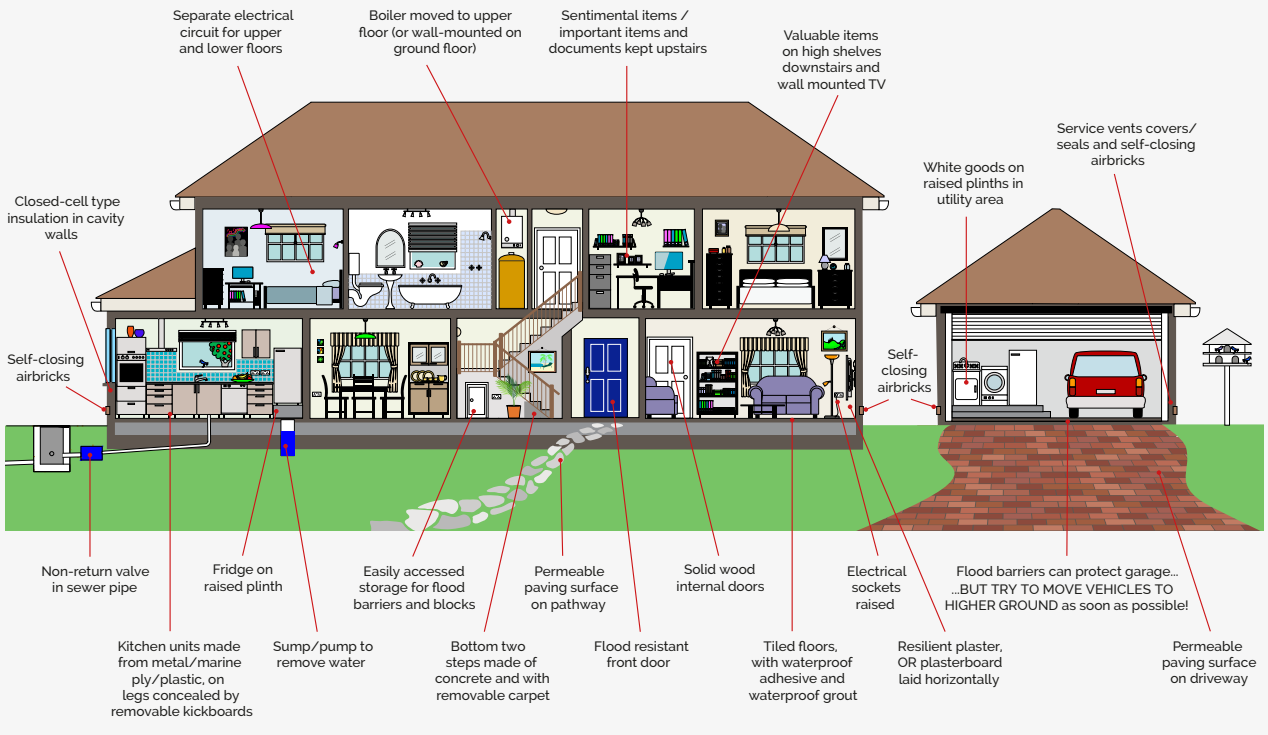
- Party walls from neighbouring properties, garages and conservatories.
- Gaps around pipes and cables that pass through walls and floors.
- The pressure created by a flood event can reverse the flow in external drains and pipes, causing water to backup and enter a home through sinks, toilets, washing machines etc. One of the most unpleasant side effects of a flood is the potential release and circulation of raw sewage inside a building.
- Cracks in brickwork.
- By breaching or overtopping the damp proof course.
- Through sub-floor voids, via air bricks or passive ventilation devices.

If you live in an existing property which is already prone to flooding, or may be at risk of flooding in the future, there are lots of things you can do to mitigate the effects of the next flood.

It is almost always unrealistic to expect to keep flood water out of your property entirely, so reducing risk of lasting damage to your property, its internal finishes and contents, and thereby speeding up recovery and re-occupation time should be your priority.

Reducing overall flood risk to a property is often a case of combining many seemingly small and often common-sense, relatively low-cost measures to make a huge difference overall. As floods are often brief, short-term events, buying time by making your property as resistant as possible to water ingress whilst making the internal finishes resilient and recoverable is the key. Adjacent are some key examples of what can be done to reduce risk.

Combined resistance and resilience measures*



REDUCING FLOOD RISK - KEY EXAMPLES

Attenuation

Where overland flooding and surface water flow from heavy rainfall is expected, having permeable external landscaping (soft-scaping) and permeable driveway paving can help to absorb and temporarily store water bearing down on your property and buy time before it reaches your door.

External Flood Barriers and Flood Gates

If you have a garden wall, consider extending it right around your property to form a protective bund. Bund walls made from cast in-situ concrete with deep footings offer the best protection, and the concrete can be disguised by cladding it with natural stone to make it more visually appealing. Create continuity of the encircling bund protection by installing special flood gates which can be closed and sealed for the duration of the flood.

None-Return Valves (NRV's) for External Drainage and Manholes

Extreme rainfall events often briefly exceed the capacity of sewers and surface water drains to cope with. This can lead to water backing up in the drains even from miles away and flooding your garden, driveway and even the inside of your house via showers and WC's with contaminated surface water and sewage.

To mitigate this risk, you should have your external drains tested to ensure they can effectively conduct water away from your property, and have none return valves fitted in manholes to ensure that if water flows the wrong way, it will not flood your garden or property from the inside out.

Sealing Pathways Through the Structure

Figure 2 of BS 85500:2015 'Potential routes of flood water entry into a building gives excellent advice on identifying pathways through the structure'. There are many structural specialist structural waterproofing products and sealants available through Delta Membranes which can address areas such as permeable brick work, wall and floor joints, and service entry points. These Delta products can be combined with others from other manufacturers such as self-closing air bricks, flood doors, flood barriers and more to produce a more integrated solution to make your building envelope as resistant to flood water entry as possible.

Flood Resilient and Recoverable Internal Finishes

If flood water enters your property, it makes sense to use internal finishes which can be easily cleaned down and which will return to their former performance levels and properties following a flood. Some examples would include tiled floor finishes, tiled upstands instead of timber skirting boards, "sacrificial" low-level plasterboard which can be removed and replaced easily, using cement based hydrophobic salt-retardant restoration wall plasters below flood level, having rugs instead of fitted carpets, moving electrical sockets to a safe height, flood resilient kitchens, hardwood furniture, moving boilers or other white goods upstairs or housing them at worktop level.

Sump & Pump Stations

Delta sump & pump station installed within a sealed structure in conjunction with resilient internal finishes may act to keep internal water levels relatively low when compared with the flood level externally. This will limit damage caused internally and after the flood subsides, the Delta sump station can provide a useful point to which remaining water and residue can be swept to be pumped out and disposed of more easily.

Combined Resistance and Resilience Measures

Keeping water out for as long as possible buys valuable time to raise/move your belongings. The diagram below, kindly provided for this brochure with permission of Mary Dhonau & Associates, Flood Resilience Consultants, illustrates many additional low cost and straightforward risk-management measures which can be simply and easily installed.

*Image supplied courtesy of Mary Long-Dhonau OBE, "Flood Mary". www.floodmary.com

Design Strategies

Designers have the ability to influence and affect change at a variety of scales. It is vitally important that designers are aware of the many different strategies that can be used to improve the flood resilience of a structure.

Successful flood resilient design can significantly reduce the exposure and vulnerability of a structure and the impact of flooding, helping those affected to recover quicker. The most successful design strategies are those which plan for both water exclusion and water entry.

The most cost-effective means of increasing a structure's resilience is to implement measures at the earliest stage possible in the design process.

Assessing the flood risk of a site is one of the most important stages of the design strategy process.

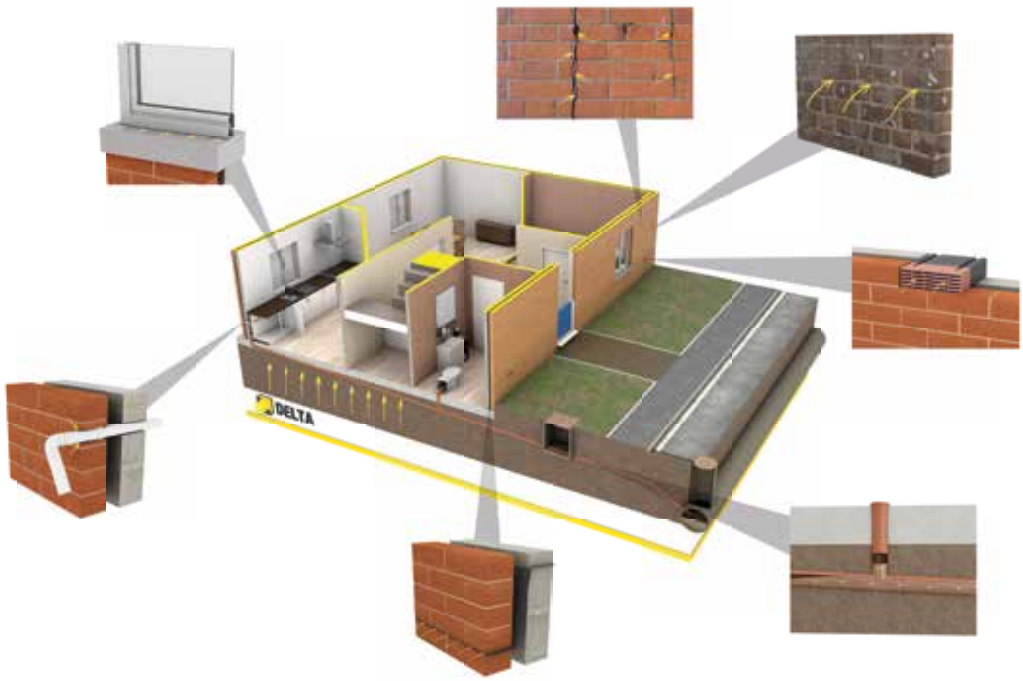
- Identifying when building flood resilience and resistance are appropriate
- Reducing the impacts of flooding from all sources
- The use of suitable materials and construction techniques

Inclusion of findings from the Flood Risk Assessment (probability, geographic extent, depth, flow velocity, and duration of event), can influence protection measures considered at the design stage.

It should be accepted that it is not always the best practice to apply every possible PFR measure to a property.

The designer's philosophy should define what they wish to accomplish in the design of their PFR measures and which principles they will use to do so. Fully assessing the risks and identifying a robust and suitable design philosophy is an important aspect when designing a continuous system, as this will not only directly impact on how the system is installed, but also in terms of any future maintenance or installation requirements, which will directly impact the property owner.

It is vitally important that designers are aware of the many different strategies that can be used to improve the flood resilience of a structure.



Ciria C790 Code of practice for property flood resilience 2020

Ciria C790 provides guidance on a variety of processes and measures which can be used to protect buildings which are prone to flooding.

The code of practice is designed for use by a variety of individuals involved in delivery of PFR (Property Flood Resilience), including:

- Property owners, occupiers and managers (residential and non-residential)
- Engineers, property surveyors, and architects
- Manufacturers and suppliers of PFR measures
- Construction contractors and installation companies (involved in installing PFR measures)
- Local authority planners, developers, and regulators specifying PFR for new build and retro fit situations (planners, building control, risk management authorities).
- Insurers, loss adjusters and insurance brokers
- Sewerage companies

The code of practice includes six standards that specify what should be achieved. The standards provide a benchmark for good practice to support the consistent and effective implementation of PFR. They are:

- **Standard 1:** Hazard Assessment
- **Standard 2:** Property Survey
- **Standard 3:** Options for Development and Design
- **Standard 4:** Construction
- **Standard 5:** Commissioning and Handover
- **Standard 6:** Operation and Maintenance

Each of the six standards is sub-divided into sections comprising aim, introduction, requirements, to ensure that the user is aware of the objectives in each standard and how to meet them. The code of practice also contains a glossary to ensure the user understands what is meant by key terms such as flood risk, flood source, flood resilience, flood resistance, flood recoverability, decontamination, drying, flood map for planning, construction design & management regulations 2015, residual risk, source, pathway, receptor, appropriate person, nominated person etc.other to explore all individual options and needs. It encourages full consideration, understanding, design, implementation, and maintenance of PFR measures.

Flood resilient design should be seen as an opportunity for 'joined up thinking' in evolving solutions, building better. There is no 'one size fits all' strategy for successful PFR. Each type of flood event has different characteristics that influence the suitability of chosen design strategy. Consideration given to construction materials, house types, ground conditions, conservation policies and user preferences should be incorporated to develop a suitable solution.

The code of practice is split into three sections to simplify use:

Ciria C790A is the main document, or framework, which needs to be followed for compliance.

Ciria C790B provides guidance and more detail on the implementation of Ciria C790A.

Ciria C790C is a supplemental document intended for homeowners and businesses. It enables the homeowner or business owner to understand what good practice looks like. It explains how the code of practice can help, gives some general PFR advice, and contains useful checklists to enable the homeowner or business owner to be confident that the PFR professionals employing the code of practice containing the six standards are complying with it.

To summarise:

Ciria C790 Code of practice for property flood resilience is a very comprehensive best-practice guidance document sub-divided into six clear stages. It can be used by PFR professionals and homeowners or business owners to interact and converse with each other to explore all individual options and needs. It encourages full consideration, understanding, design, implementation, and maintenance of PFR measures. Flood resilient design should be seen as an opportunity for 'joined up thinking' in evolving solutions, building better. There is no 'one size fits all' strategy for successful PFR. Each type of flood event has different characteristics that influence the suitability of chosen design strategy. Consideration given to construction materials, house types, ground conditions, conservation policies and user preferences should be incorporated to develop a suitable solution.

Choice of Design Strategy

The 3 main choices of design strategy are:

- **Flood Resistance**
- **Flood Resilience**
- **Flood Resistance, Resilience and Recoverability**

(The above terms are defined elsewhere in this brochure)

Designers should take into consideration costs and benefits of suitable approaches, end user needs, end user expectations, end user budget, operation and performance requirements, and future planned maintenance of measures.

All specified PFR measures should make use of products and processes which are compliant with recognised standards and are subject to warranties.

Collaboration between manufacturers and manufacturer-registered installers plays a vital role. The sharing of knowledge, opinion and insight is essential to the success of the PFR measures.

It should be accepted that it is not always best to apply every possible PFR measure to a property. For example, where structural integrity is thought to be at potential risk from hydrostatic pressure during a flood, a water entry strategy may be preferred.

Flood Resistance Design

Flood Resistance measures are designed to keep water out of a structure. This is done by sealing all openings around the ground level of a property and preventing water from being allowed to seep through.

This approach is typically recommended to a maximum depth of approximately 0.6m, as floods of depths exceeding this may cause structural damage to some properties. Flood resistance measures cover a range of products in order to seal all apertures around the perimeter of a building.

Flood Resilience Design

Flood Resilience measures are incorporated into the building's fabric and/or fixtures and fittings to reduce the adverse consequences caused by flood water entering the property.

Flood Resilience measures are not designed to keep water out of your property, but are installed to reduce the overall impact of a flood event by reducing damage caused.

Resilience design should take into account:

- Water entry
- Recoverability
- Cleaning and Sanitisation
- Drying Times
- Re-Occupation
- De-Mountable/Replacement/Sacrificial Materials
- Bespoke Products and Measures
- Situation Monitoring
- Planning for the Future

Flood Resistance, Resilience and Recoverability

Combining Flood Resistance, Resilience and Recoverability measures offers the most integrated and effective approach to enable faster recovery of a building after a flood event. This approach means that should a flood exceed the height of your resistance measures, the damage to the building from floodwater will be more limited, and recovery and reoccupation times will be optimised.

Detailing

The effectiveness and reliability of PFR measures rests upon correct implementation of design, detailing, installation, and ongoing operation maintenance requirements of the solution.

Typical categories which require close scrutiny and detailing are:

- Service penetrations through the building envelope
- Protection of Internal/External thresholds
- Backflow prevention to design out risk of flood water ingress from external drains
- Water-tightness of construction joints and structural junctures
- The elimination of, or access to hidden voids and cavities to allow cleaning & sanitization
- Continuity of flood resistance measures to, or above DPC level (according to flood risk)
- Product compatibility with appropriate certification and/or scope for testing during installation
- Continuity of systems to ensure all PFR elements such as waterproof coatings and flood door frames can be integrated and linked using appropriate sealing products

PFR measure should be detailed and installed in accordance with the manufacturer's guidelines.

Many PFR products require maintenance and cleaning to ensure they continue to work. Annual servicing or periodic maintenance may be required in order to uphold the warranty and guarantee of certain products.

Consequences of inadequate detailing can be:

- Water ingress
- Trapped flood water, resulting in dampness, salt contamination, bacterial growth and condensation
- Excessive latent moisture content in the structure, resulting in direct deterioration of materials and condensation
- Odours originating from trapped bacteria in inaccessible none resilient and none-recoverable materials, such as porous floor insulation below a floor screed, or in a cavity wall
- Sewage/contamination originating from external sewers where NRV's have not been fitted, or from black water or grey water remaining trapped in none-resilient materials
- Disruptive and excessive strip-out and remedial works following a flood, due to lack of inclusion of resilient and recoverable materials at the design stage
- Structural damage or de-stabilisation of the building, requiring specialist input to rectify
- Worst-case scenario, structural collapse

Careful detailing plays a crucial role in PFR design. Whichever strategy or combination of PFR measures is adopted, consideration should be given to the correct detailing to design out potential risk.

Flood Reports and Proposals

Flood Reports and design proposals should clearly summarise the design objectives. These should be provided to the client with an appropriate level of detail, using suitable language to communicate in a concise and logical manner for the client to understand.

The report should highlight any major risks or vulnerabilities identified during the site survey and should flag up and uncertainties. The report should include all relevant construction details, property characteristics and susceptibility of the structure to flooding given its surroundings, design, structure, materials used, condition and adaptations.

A suggested format for reports:

INTRODUCTION:

- Property level flood risk assessment
- Source identification and analysis
- Pathway identification and analysis
- Receptor identification and analysis
- Understanding the flooding likelihood at the building location
- Risk assessment

OBJECTIVES:

Define parameters in proportion to risk assessment above
Define user expectations

NOMINATIVE STANDARDS:

BS 85500:2015
BS 8102:2022

OTHER REFERENCES:

CIRIA C790:2020
Bonfield Report, etc.

PROPERTY SURVEY:

Establish condition of construction/building fabric

- Dilapidated
- Flood damaged
- New build
- Traditional
- Current level of PFR established
- Current ease/practicality of recovery established

FINDINGS:

Physical observations (the floor had suffered from heave, etc.)
Note moisture readings or RH readings where applicable

OPTIONS FOR DEVELOPMENT AND DESIGN:

Re-define user expectations
What potential PFR options there are in light of the findings
Cost v risk/benefit discussion with end-user
Define future maintenance and servicing of PFR measures

CONCLUSIONS & RECOMMENDATIONS:

Step by step solution
List all PFR measures to be installed and why
Define in principle all appropriate persons and agencies to be involved in design and installation of PFR measures and what their potential roles will be.
State how the proposed PFR solution meets current best practice guidance
State how proposed PFR solution meets client expectations
State any limitations on what the proposed PFR measure will or will not achieve
Define any likely ongoing service and maintenance requirements
Define role of end user/client in installation of certain de-mountable measures during a flood event

OUTLINE SPECIFICATION:

A step-by-step list of each consecutive stage of the installation, from very start to finish, defining who does what and when, to be used as a basis for a later site meeting involving all parties, at which stage this can be tweaked or amended accordingly, and agreed between all parties.

GENERAL NOTE ON O&M MANUAL, HANDOVER DOCUMENTATION, GUARANTEES AND POST-INSTALLATION REQUIREMENTS:

A final section to note the requirement for the client/end user to receive a comprehensive set of documents relating to the above, and to state that the installation must be inspected and signed off by an appropriate person at project completion.

Flood Resistance, Resilience and Recoverability

CASE STUDY: BRE FLOOD RESILIENT HOME

The BRE Victorian terrace, originally built in 1855, was transformed into three energy efficient terraced homes to create a living refurbishment laboratory. The 3 properties within the Victorian terrace are: The Flood Resilient Home, The Dementia Friendly Building, and a Nursery.

The Flood Resilient Home has been adapted to be resistant to flooding from external flood water up to 600mm (2 feet) deep, and to be resilient and recoverable due to the effects of being flooded to greater depths. It has been designed with speedy flood recovery in mind, and be suitable to move back into in a very short time after a flood incident.

The BRE Flood Resilient Home aims to showcase the benefits of flood resilient and recoverable materials, which could be installed in a typical home like this, that will minimise damage caused by subsequent flooding; It also shows how simple measures such as placing electrical sockets and appliances higher up walls and using doors and windows with flood resisting seals can help minimise future damage. And, if water does get in, an automatic Delta sump and pump unit connected to discreet inlet drains in the floor quickly pumps water out of the house again. This aims to keep water levels inside low relative to those outside, thereby minimising damage, and it also provides a useful clean-up point to which residual flood water and contaminants can be swept and disposed of.

In 2016 Delta Membranes Systems was delighted to attend a series of meetings chaired by the BRE to discuss Flood Resilience measures in a bid to reduce the suffering experienced by thousands of home and business owners whilst considering the vast cost implications to homeowners and insurers in making properties more resilient in the face of flooding.

Delta Membrane Systems Limited produced the specification for the BRE Flood Resilient Home with the assistance of John O'Brien, BRE Associate Director Construction Innovation, and Delta Registered Installer Proten Services Ltd.

This specification for the BRE Flood Resilient Home uses the same specialist technology and products Delta have used for many years in basements and below ground structures, with additional consideration given to how we could adapt these to work in flood situations. In addition to flood water entering through openings to properties (such as doorways, air bricks and windows) buildings also suffer in some cases with ground water, driven by flood water displacement, rising up through the floor construction, causing even more extensive damage.

The specification centres around the use of Delta specialist water-blocking products, known as Type A "barrier system" products to increase the integral water resistance of the structure itself, backed up by an internal Type C "drained protection" system, incorporating a Delta MS500 cavity drainage wall membrane, a Delta MS20 cavity drainage floor membrane, hidden Delta perimeter drainage channels and floor-mounted drainage inlets, and a Delta Dual V3 sump and pump unit with high level alarm and battery backup.

How Does This Technology Work?

Flood water enters a home causing extensive damage to the fabric which leads to Insurers appointing a loss adjuster to assess the extent of the damage and the claim. The strip-out begins and typically follows with the implementation of dehumidifiers to dry out the structure, this takes many months and Insurers bear huge financial burden with not only this process, but also with the process of reinstatement costs and providing alternative accommodation for their clients in the interim. The BRE states that masonry under typical conditions will dry out at a rate of approximately 1 inch per month per thickness of substrate.

Flood water also contains contaminants which require the walls and floor to be sterilized. In order to significantly reduce downtime, Delta cavity drainage membranes (Delta MS 500 for walls and Delta MS20 for floor slabs) can be fitted. These dimpled membranes comprise an HDPE extruded sheet which acts as an air gap and a vapour barrier, thereby providing an immediate barrier against the effects of salts and contamination, so allowing fast track reinstatement of internal finishes, and at the same time allowing for walls to dry passively over time.

Prior to the Delta cavity drainage membranes being installed, we enable flood water entering the structure to be controlled and drained away by installing Delta perimeter drainage channels rebated into the floor slab. The drainage channels collect penetrating water from behind the Delta wall and floor membranes and immediately direct it to the Delta packaged pump station which houses two submersible pumps. Pumping capacity depends upon which Delta pump is specified, but at the lower end of the performance spectrum a Delta Dual sump and pump station will discharge approximately 2 litres per second per pump, and some Delta pumps will discharge approximately 6 litres per second per pump.

With a further modification to compliment the effectiveness of the perimeter drainage channel system, 110mm standard underground plastic drainage pipework can be laid beneath the floor slab with periodic 90-degree upturns which finish flush with the floor finishes. These can be located in unobtrusive locations and covered with a small grill to provide a series of secret open floor gullies. This will pick up any flood water that may have seeped past Type A barrier system products or other flood defences such as floor doors or flood barriers, and drain it direct to the sump station, so keeping internal water levels low and reducing damage. Floors are typically tiled to allow fast cleaning and recovery, but consideration should also be given to installing flood resilient insulation, screeds, and sacrificial plasterboard. Access to hidden voids should be considered to allow thorough cleaning out of contaminated water and associated bacteria, which could otherwise remain trapped and propagate long after the flood event itself.

CASE STUDY: EDENSIDE BARN

Edenside Barn is a privately owned barn-conversion property which featured as part of the widely-acclaimed Cumbria Flood Resilient Showcase Project in 2017, following the devastation brought by Storm Desmond in 2015.

The property is located on idyllic farmland close to the banks of the river Eden in the picturesque Eden Valley, Cumbria. Edenside Barn has periodically suffered with river flooding when the river Eden has burst its banks, leaving it uninhabitable and the owners having to seek alternative accommodation.

In conjunction with Mary Dhonau community flood specialist, Adler and Allen disaster recovery specialists, and Aquobex specialist manufacturer of flood resilient products, Delta Membrane Systems Limited was asked to contribute to the design and installation of a robust flood resilient and recoverable solution incorporating Delta's unique technical knowledge and products.

...a highly efficient, simple, integrated, and relatively low-cost solution produced by collaboration and "joined up thinking" between diverse specialists.

Delta's solution incorporated best practice guidance given in **BS 85500:2015 Flood resistant and resilient construction – guide to improving the flood performance of buildings,** which advocates realistic strategies which plan for water exclusion but also allow for water entry. Delta Registered Installer Peter Cox Limited volunteered their time to install the Delta products on this project.

The existing structure consisted of solid stone walls, some internal block wall linings, and a good quality concrete floor slab. All potential pathways for flood water ingress were identified and sealed.

The interfaces between the wall and floor needed to offer a watertight seal to inhibit ingress between the floor slab and the wall which was achieved by pointing in using concave fillets of slightly expanding Delta Koster Repair Mortar Plus. The water resistance of internal pointing between joints in the stonework was also improved using Delta Koster Repair Mortar Plus.

The existing internal substrates were treated using Delta Koster Polysil TG500, a surface sealing anti-lime and salt-inhibiting primer, and the internal faces of the stone walls were coated using Polyurea, a spray-applied durable plastic coating, with two coats of Delta's water-based Epoxy over the existing floor slab. These products worked together to provide an impervious, non-absorbent, non-moisture-emitting, recoverable finish, prior to ceramic floor tiles sealed using waterproof grout being applied over.

Waterproofing continuity with existing external wall-mounted frames for existing external flood barriers was achieved from inside to outside using Delta Koster NB1 Grey Crystalline Slurry and Delta Koster FSV flexible joint sealant.

Internal "sacrificial" horizontal plasterboard linings were installed over an internal metal track dry lining frame, with a horizontal joint at worktop height, covered by a removable dado rail. In the event of a flood, this low-level plasterboard could easily be removed to allow re-fixing later if it could be saved in time, or complete replacement, and the void behind could be accessed for cleaning.

Overall, the above specification represented a highly efficient, simple, integrated, and relatively low-cost solution produced by collaboration and "joined up thinking" between diverse specialists.

Design Principles

Delta Design Principles

Property Flood Resilience (PFR) is always a bespoke, design-led approach informed by the unique circumstances of each individual property. In essence, and in its purest sense, it is an approach to changing the built environment to better deal with flood risk.

Maintainable Designs

PFR measures should be designed and installed with practicality of installation and maintainability in mind. All components of the Delta system should be accessible for both inspection and maintenance.

Flood Testing/Integrity Testing

The integrity of the PFR measure should be checked and inspected at each stage of installation and immediately upon completion. If there is a delay before final handover or the laying of permanent coverings, or the property should flood in the interim, a second inspection is strongly recommended. As with all waterproofing-based systems, the scope for testing during installation should be considered as part of the design.

Registered Installer Network

As manufacturers of quality systems, it is imperative for Delta to work with quality installation companies. At Delta, we pride ourselves upon having built a network of highly qualified, reliable, Delta Registered Installers. The Delta Registered Installer Network is an elite group of experienced Delta System installers who share our values – a dedication to quality, authenticity, and exceptional customer service. Our Delta Registered Installer partners all have extensive experience of working with and installing Delta Systems. This means you can be confident of a timely, efficient installation, carried out with the minimum of disruption and fuss. All Delta Registered Installers adhere to strict membership criteria and are required to attend regular training sessions, as well as demonstrating quality of workmanship before accreditation.

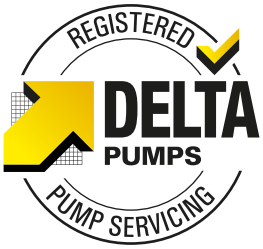
Delta Pumps Registered Installer Network

Sump & Pump systems can form a critical part of bespoke PFR measures and where installed, the sump and pump systems must be maintained on a regular basis. Delta recommends that a qualified pump engineer should examine and service the pumping equipment at least every 12 months. Following initial commissioning of the system, a service is recommended within the first six months. Sump pumps, being mechanical devices, may fail or lose efficiency if not maintained. Regular servicing of sump pumps will improve efficiency and extend the life of the pumps. All Delta pumping systems can be commissioned, maintained and serviced by a Delta Registered Pump Servicing provider or the Delta Registered Installer.

A certified Delta Registered Pump Servicing Network provider can offer a 5-year extended warranty period on Delta Pumps (subject to terms and conditions). Extended warranties are a way of obtaining extra protection and peace of mind for Delta Pumps in addition to the standard warranty offered. Delta Registered Pump Servicing Network providers will register the Delta Pump on the customer's behalf for an extended manufacturer's warranty.

Guarantees

Delta Membrane Systems Limited offer a 30-year Product Guarantee on membranes, seals, and fixings when a Delta Registered Installer has installed a Delta Type C Cavity Drainage System.



Type C Membranes

Delta MS 500 Fire Retardant

Description

Delta MS 500 Fire Retardant is an 8mm studded cavity drain membrane with a Euroclass fire rating of B-S2, d0 (EN 13501- 1:2018), suitable for use on internal faces of walls, floors and vaulted ceilings as part of a water management or damp proofing system.
Roll Size: 2.4m x 20m

Features

- 8mm studded profile
- BBA Approved
- Compressive Strength: >250 kN/m^2
- Drainage capacity: 2.25 l/s m^2
- BS 8102:2022 Type C Waterproofing Protection
- Suitable for Waterproofing and damp proofing
- Suitable for flood resilience (PFR)
- Resistant to chemicals, root penetration, rotproof

Product Code
DMS 850

Delta MS 500

Description

Delta MS 500 is a virgin HDPE, 8mm studded Type C cavity drainage membrane that is suitable for use on internal faces of walls, floors and vaulted ceilings as part of a water management or damp proofing system. Delta MS 500 provides an effective barrier to the transmission of salts and other contaminants.

CAD files are available for download from our website.
Visit: www.deltamembranes.com/technical/technical-drawings-flood-resilience-resistance-and-recoverability/

Features

- 8mm clear studded profile
- Compressive Strength: >250 kN/m^2
- Drainage capacity: 2.25 l/s m^2
- BBA Approved
- Resistant to chemicals, root penetration, rot proof

Product Code
DMS 005 - 2m x 20m
DMS 007 - 2.4m x 20m

Delta MS 20

Description

Delta MS 20 is an 20mm studded, Type C cavity drainage membrane that is suitable for use on internal surfaces of floor slabs, and also on internal surfaces of retaining wall structures where a higher drainage capacity is required. This virgin High-Density Polyethylene (HDPE) membrane creates a large 14 litres per square meter void, ideal for high levels of water management. Roll Size: 2m x 20m

Features

- 20mm studded profile suitable for higher volumes of water penetration
- BBA Approved
- Compressive Strength: >150 kN/m^2
- Drainage capacity: 10 l/S m^2
- BS 8102:2022 Type C Waterproofing Protection
- Suitable for Waterproofing and damp proofing
- Suitable for flood resilience (PFR)
- Resistant to chemicals, root penetration, rot proof

Product Code
DMS 009

Delta PT

Description

Delta PT is an 8mm studded, Type C cavity drainage membrane with a meshed face for direct application of render or adhesive dabs that is suitable for use in basement waterproofing for new and existing structures. Delta PT can also be used in above ground application to provide a damp proof barrier and to isolate internal finishes from hygroscopic salt contamination.

Features

- 8mm studded profile
- Compressive Strength: 70 kN/m^2
- Drainage capacity: 5 l/s m^2
- An effective barrier to the transmission of salts, liquid water and water vapour
- Resistant to chemicals, root penetration, rot proof, neutral towards drinking water

Product Code
DMS 001 - 1.5m x 10m
DMS 002 - 2m x 20m

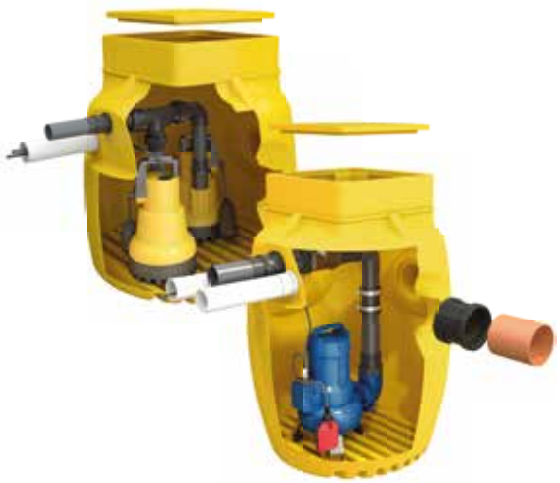
Delta Packaged Pumping Stations

Description

The concept of a Drained Cavity System is to collect and manage any groundwater which breaches the integrity of a structure by managing, collecting and discharging such free water via a suitable evacuation point such as a Delta Packaged Pump Station.

Delta offer a comprehensive range of Package Pump Stations which are suitable for the evacuation of Groundwater, Surface water, Foul water and Flood water.

In additional we offer bespoke chambers for larger properties.



PuddlePal

Description

The PuddlePal is a submersible emergency dewatering set. It contains a stainless steel pump with built-in level switch, integrated check valve and mounting bracket among other beneficial components.

The PuddlePal can be used for emergency dewatering and is a plug and play product that can be used anywhere that flooding may occur.

FloodBuddy

Description

The FloodBuddy has been developed to be used primarily in emergency flooding situations, yet it can also be utilised for dewatering flat areas, such as basements/cellars, commercial premises, or areas liable to flooding. The dewatering kit consists of a stainless steel pump with built-in level switch, mounting bracket, 10m pump cable and 10m of lay flat hose with quick release couplings. The particle size should not exceed a size of 10mm.

Alarms and Battery Backups

Alarms and Control Panels

Description

High level water alarms or high-level alarms provide a warning when high water levels are detected in Packaged Pumping Stations (sump pump chambers) or if there is an increase in volume of water entering a property.

The Delta HLA is an independent high water level alarm with an 85 dB audible alarm and LED status display on the front fascia. The Delta HLA is simple to install and offers three volt-free contacts for connection to external systems.

Features

- An internal battery ensures continuous protection in the event
- of mains power failure
- Quick and simple installation
- Robust and reliable high water alarm
- Includes a mini float switch and Delta Float Shroud
- LED's for visual status and warning
- Mute and reset buttons
- Three volt-free contacts for connection to external systems
- Can be retrofitted

Battery Backups

Description

The Delta Battery Backup is specifically designed for Packaged Pump Stations (submersible pumps/sump pumps) when there is a loss of mains power.

The Delta's Battery Backups provide abundant battery backup power, so your Packaged Pump Station (sump pumps) continue working through short and medium length power outages. Safeguarding your sump pump equipment and keeping basement and structures remaining dry.

Simple to use and easy to install.

Features

- Specifically designed for sump pump applications
- Capable of running primary or secondary pump(s)
- Wall-mounted for safety
- Industry leading backup power
- Digital display to show status and comprehensive fault codes
- Virtually inaudible and offers tamper-proof installation

Waterproofing Products and Ancillaries

Koster NB 1

Koster NB1 is a mineral-coated waterproofing slurry containing crystallising and capillary-plugging agents. It can be used for waterproofing against ground moisture and for non-pressurized and pressurized water.

Features

- Positive and negative side waterproofing against pressurized water
- Resistant to chlorides, sulphates and phosphates
- Penetrates the surface, where crystallization leads to inseparable waterproofing-substrate bond. Does not contain corrosion-promoting ingredients
- No VOC emissions
- Substrate does not have to be continually kept wet to allow curing
- Suitable for new construction and refurbishment/waterproofing of existing structures

Koster Repair Mortar Plus

Koster Repair Mortar Plus is a waterproof, fast setting, slightly expanding repair mortar with excellent adhesion (even to old building material substrates). With the addition of Koster SB Bonding Emulsion, it can be used as a PCC (polymer-modified cement concrete) mortar.

Features

- Watertight (positive and negative side waterproofing)
- Fast Setting (seamless, easy application)
- Slightly expanding
- Excellent adhesion
- Can be applied to all mineral substrates
- Suitable for watertight repairs and touch-ups to substrates. Can be used internally and externally on concrete, brickwork, blockwork or masonry

Koster KD System – Waterstop

Koster KD System – Waterstop (including KD Base, KD Blitz and KD Sealer). Koster KD System stops active water ingress and effectively seals off pressurized water from the negative side within seconds!

Features

- Waterproof sealing compound
- Fast Setting
- Can be applied to all mineral substrates
- Suitable for watertight repairs to substrates
- Watertight finish
- Can be used internally and externally on concrete, brickwork, blockwork or masonry

Koster KB Flex 200

Koster KB Flex 200 is a permanent plastic sealing compound ideal for sealing pipe and cable penetrations, small cavities, and for custom-detail waterproofing solutions requiring resistance to moisture and pressurized water.

Features

- Waterproof sealing compound
- Watertight finish
- Ideal solution for sealing pipe and cable penetrations
- Does not dry out
- Can be applied to dry, moist or wet substrates
- Immediate functionality
- Excellent adhesion to a variety of substrates

Koster Deuxan 2C

Koster Deuxan 2C is a robust, crack-bridging, 2 component, polymer-modified bitumen thick film sealant for positive-side waterproofing of basements and below ground structures.

Features

- BBA Approved Koster Deuxan 2C is suitable for use as a bonded, Type A Barrier protection waterproofing product, as defined in BS 8102:2022
- Positive side waterproofing against pressurized water
- Can be used externally on concrete, brickwork, blockwork or masonry, or as an internal damp proof membrane on solid floors to provide an effective barrier to non-pressurized rising capillary dampness.

Koster PU Flex 25

Koster PU Flex 25 is a highly elastic, one component, low modulus polyurethane joint sealant. PU-Flex 25 is a remarkable sealant used for between concrete, mortar, brickwork, natural and synthetic stone, metal, steel, aluminium, wood, ceramic tiles and rigid plastics.

Features

- Highly thixotropic with positive workability
- Non-sagging
- Polyurethane based
- Good UV resistance
- Excellent adhesion to typical construction materials
- Seamless easy application using a cartridge gun

Waterproofing Products and Ancillaries

Delta Water Based Epoxy Resin

Description

Delta Water Based Epoxy Resin is suitable for all applications where concrete or masonry requires waterproofing and protection. It is applied in the same manner as ordinary emulsion paint with the added benefit of application in damp conditions. Once dried, Delta Water Based Epoxy leaves a tough, non-toxic, waterproof, easy to clean surface.

Features

- As a membrane to prevent raising damp in floors or anti-lime treatment of new concrete
- As a general waterproofing and decorative finish for all brick, concrete, cement and masonry surfaces
- For damp surfaces where other paints cannot adhere
- As a tank-lining for protection against mild chemicals
- All other applications where a waterproofing coating is required
- Non-Toxic, tough, and durable

Product Codes

DMS 485, DMS 486, DMS 487, DMS 488, DMS 144, DMS 148, DMS 149, DMS 150

Delta Puddle Flange

Description

A Delta Puddle Flange offers a tight, waterproof rubber seal around the outside of the plastic pipe upturns when installing Delta Modular Drainage. A Delta Puddle Flange is recommended to prevent ground water ingress through the 110mm pipe work/RC slab, or pipe penetration/reinforced concrete wall juncture. Delta Puddle Flanges are available in a range of diameters varying between 32mm and 160mm.

Features

- Waterproof seal for modular drainage pipe upturns
- Prevents groundwater penetration through the joint between pipe penetrations and concrete structure
- Robust and easy to install

Product Code

DMS 161

Delta Drainage Channel and Ancillaries

Description

Delta Channel is bedded into a pre-formed rebate (recess/channel chase) at the floor/wall junction and is suited for use in conjunction with the Delta cavity drain Membrane range. Pre-formed holes within the Delta Channel allow for water to enter, then drain into a suitable packaged pumping station or other suitable discharge point. Access points within the Delta Channel should be installed to allow for maintenance and inspection.

Features

- Yellow for ease of cleaning, inspection and maintenance
- Channels water to a suitable evacuation point
- Compatible with all Delta basement drainage connectors
- Compatible with Delta Inspection Ports and Access Ports to allow for cleaning, inspection and maintenance
- Available with Upstand/ without Upstand

Product Code

DMS 207 Channel with Upstand
DMS 208 Channel without Upstand

Delta 110mm Drainage Outlet

Description

Delta 110mm Drainage Outlet is designed to connect Delta Channel to 110mm standard underground pipe. The 110mm Drainage Outlet consists of a 90° PVC bend and a PVC male coupling which is fitted to the base of Delta Channel to allow water to travel from the conduit to the water collection point (sump pump). The 110mm Drainage Outlet can also accept an inspection port and has the ability to accept cross floor channels.

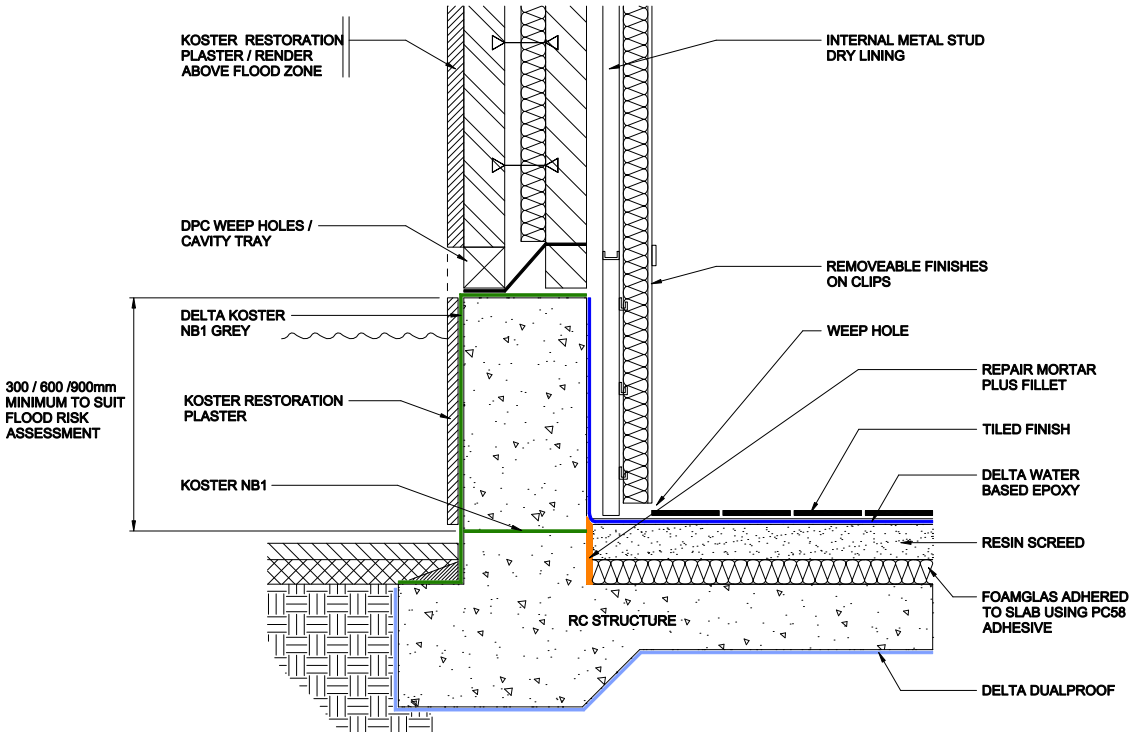
Features

- Connects Delta Channels to 110mm standard underground pipe
- Compatible with Delta Channel Ancillaries

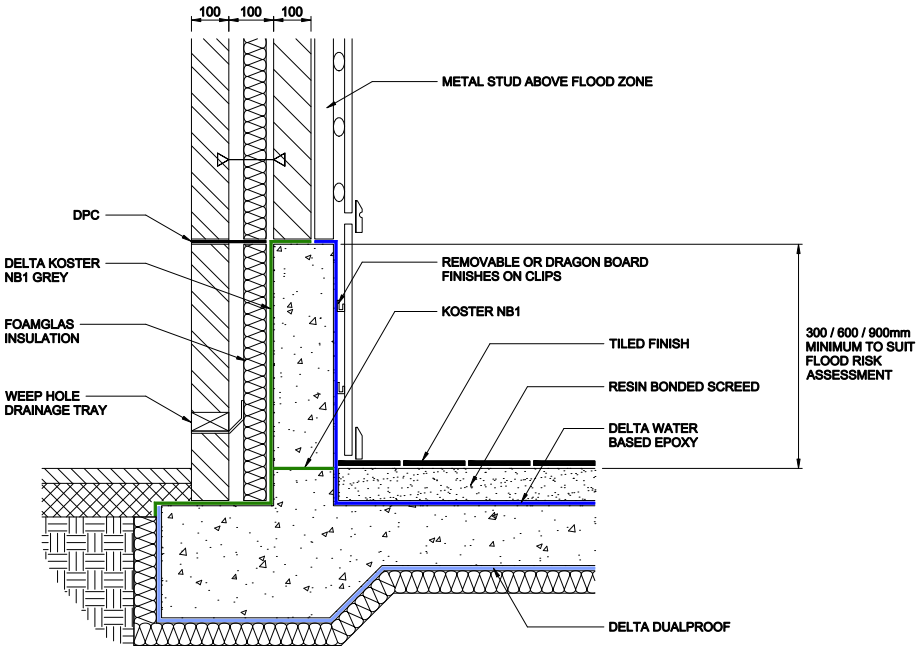
Product Code

DMS 128

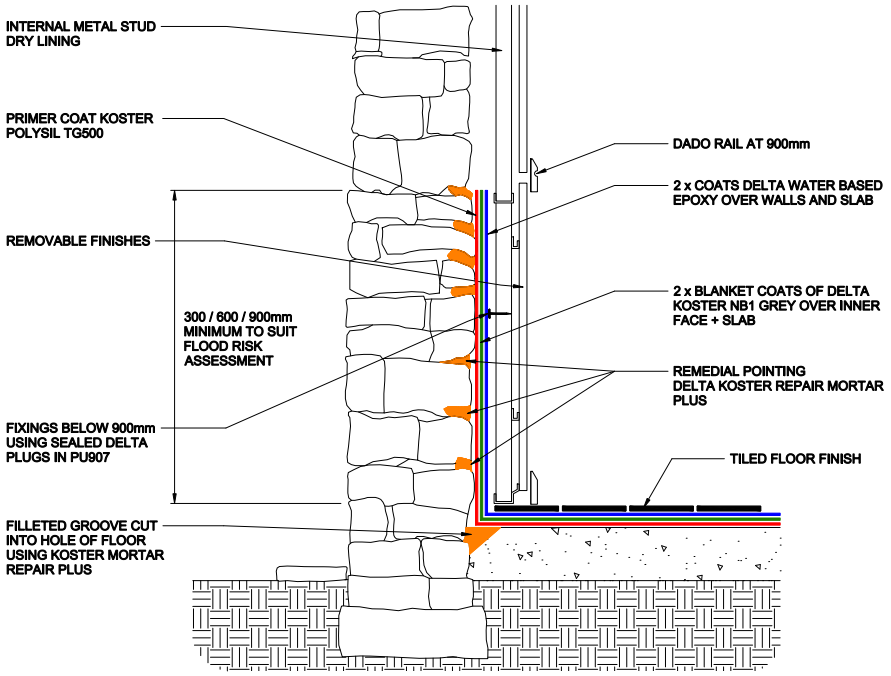
Flood Resistant House Type 1 - New Build- Flood Plain Resistance and Recoverability



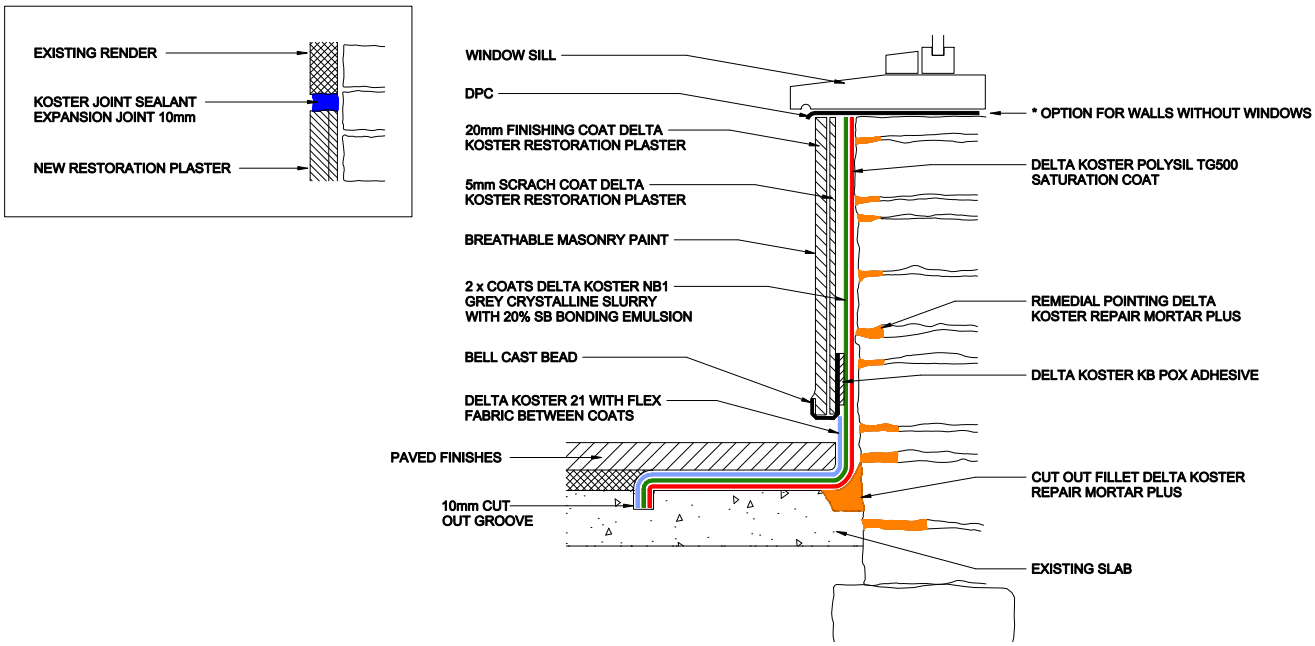
Flood Resistant House Type 2 - New Build - Flood Plain Resistance and Recoverability Exposed Brick Work Outer Leaf Construction



Flood Resistance and Recoverability - House Type 3 Traditional Stone Construction - Conservation Area "Low Cost" Option - Recoverable With De-mountable Finish / Solid Floor Construction



External Flood Resilience Existing Masonry Wall - Detail 1



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